Docket No. SA-537

Exhibit No. 6-W

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Boeing Presentation
Airplane Cabin Crashworthiness & Occupant Protection

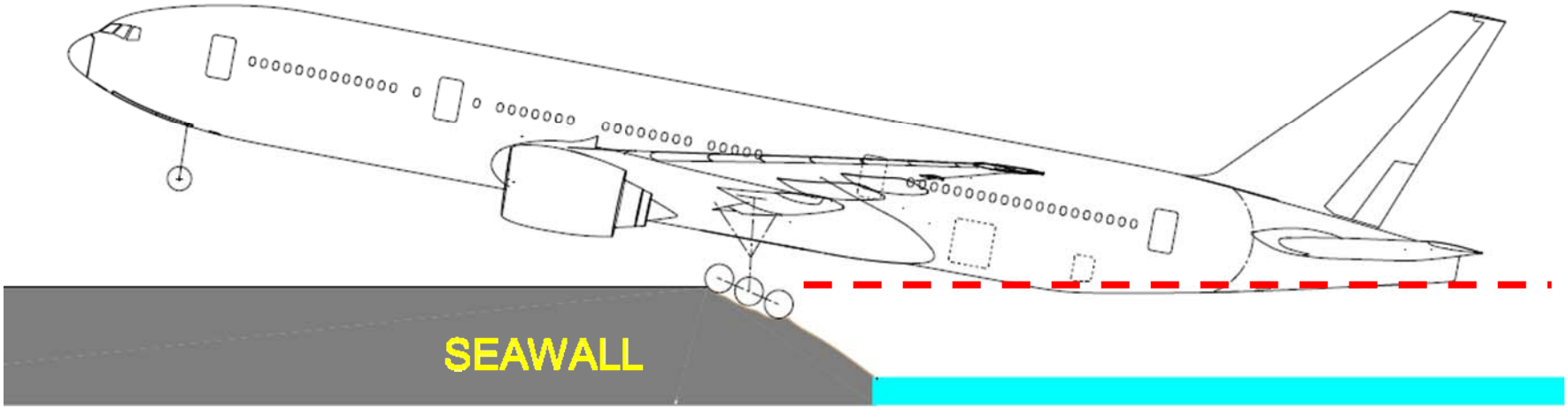
(9 Pages)

NTSB Investigative Hearing
777 Landing Accident at San Francisco
Panel 5 – Airplane Cabin Crashworthiness & Occupant Protection

Bruce Wallace
Evacuation Systems Engineer
Associate Technical Fellow
Boeing Commercial Airplanes

The Impact Sequence—Multiple Severe Events

- The main landing gear and aft fuselage impacted the seawall at over 100 kts, resulting in severe longitudinal impact loads.
  - The main landing gear separated from the wings.
  - The aft fuselage structure was heavily damaged, resulting in separation of the tail and the release of the aft galleys and cargo onto the runway.
- The airplane continued down the runway resting on the nose landing gear and the engines.



The Impact Sequence—Multiple Severe Events

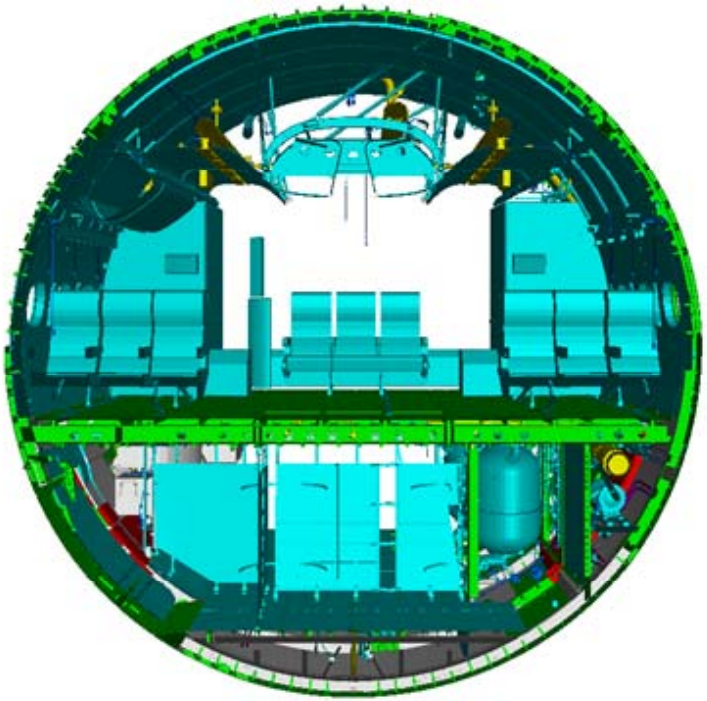
- The left engine separated.
- The airplane rotated 330 degrees counter-clockwise, pivoting about the nose wheel while sharply inclined to the ground.
- The fuselage was subjected to severe vertical and side loads at the end of the rotation when the fuselage impacted the ground.
- The right engine separated.
- As the airplane slid to the final position, the fuselage sustained additional severe side loads that peeled open the lower aft fuselage.
- Fire ignited at right engine oil tank, outside the fuselage. Video showed black smoke coming from Door 1L approximately 15 minutes after the airplane came to rest. Smoke or fire did not prevent complete evacuation of the airplane.

Safety Design Goals

- Three safety design goals:
  - *Survive an impact*
  - *Survive a fire*
  - *Evacuate the airplane*
- The airplane performed extremely well with respect to each goal despite being subjected to severe longitudinal, vertical, and side loading.

Surviving an Impact

- The Boeing 777 structure and interior are designed to exceed the dynamic ground, dynamic flight, and crash landing load certification requirements.
- Passenger seats and restraints are designed to exceed the static and dynamic load certification requirements, including 16g forward dynamic loads and 14g downward dynamic loads.
- Despite multiple severe impact loads, the passenger seating area remained intact, the passenger seats and restraints provided protection, and the overhead stow bins did not fall on the passengers or impede evacuation.



Airplane structure provided protection during multiple severe impacts

Surviving a Fire

- Boeing 777 fire protection features are designed to resist fire, allowing time for passenger evacuation.
  - Engines and main landing gear are designed to separate to prevent fuel tank rupture.
  - Insulation blankets and cabin materials resist fire propagation.

- The main landing gear and the engines separated as designed during the impact sequence, preventing rupture of fuel tanks and avoiding a wide spread, fuel-fed fire.

Fire protection features allowed time for passenger evacuation

Evacuating the Airplane

- The Boeing 777 is designed and tested to enable evacuation of all passengers and crew within 90 seconds, as required by FAA regulations.
  - Test done with half of exits blocked, under night lighting conditions.
- Features that expedite evacuation:
  - Simple operation exits and doors;
  - Seats and other interior features stay secure, keeping aisles free; and
  - Automatic, self-inflating escape slides.

- Despite the structural damage from the multiple severe impacts, doors opened, seats and interior monuments stayed clear of the aisles, and passengers were evacuated from the airplane.

Evacuation system enabled a timely evacuation

Boeing's Commitment to Safety

- Even after sustaining multiple impact loads that exceeded design and certification requirements, the 777 airplane helped passengers and crew
  - Survive the impact
  - Survive the fire
  - Evacuate the airplane

- The performance of the 777 in this accident highlights the benefits of the aviation industry's work to increase airplane safety and survivability.